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(54) Title: A HYDROPHILIC COATING AND A METHOD FOR THE PREPARATION THEREOF

(57) Abstract

A cross–linked hydrophilic coating comprising a cross–linked polyvinylpyrrolidone or copolymer containing N–vinylpyrrolidone, said coating having a higher degree of cross–linking in the parts near the substrate. The hydrophilic coatings of the invention have a high abrasion resistance giving the devices a long life time.

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TITLE

A hydrophilic coating and a method for the preparation thereof

FIELD OF THE INVENTION

The present invention relates to a hydrophilic coating and to a method for the preparation thereof. Furthermore, the invention relates to a medical device provided with such a hydrophilic coating and a method for providing a medical device or other product with a hydrophilic coating as well as the use of a polymer containing a hydrophilic reactive group for the preparation of a medical device or instrument comprising a hydrophilic coating being crosslinked.

A hydrophilic coating according to the invention may be used for coating the surface or a part thereof of a wide range of products in order to impart give the surface a low friction. As examples of products which may be provided with a surface having a low friction when wet are medical instruments such as catheters, endo and laryngoscopes, tubes for feeding, or drainage or endotracheal use, condoms, barrier coatings, e.g. for gloves, wound dressings, contact lenses, implantates, extracorporeal blood conduits, membranes e.g. for dialysis, blood filters, devices for circulatory assistance, packaging for foodstuff, razor blades, fishermen's net, conduits for wiring, water pipes having a coating inside, sports articles, cosmetic additives, mould release agents, and fishing lines and nets.

BACKGROUND OF THE INVENTION

The application of hydrophilic coatings on medical devices has become a very important method to improve biocompatibility between living tissue and the medical device. Another important property of hydrophilic coatings is to reduce the friction and to render biomedical devices slippery when wet. Medical devices like catheters, guide-wires, endoscopes etc. are often sliding in direct contact with the surface of living tissue when in use. Catheters and guide wires may e.g. be introduced into the blood vessels or a catheter for intermittent catherisation of the bladder is introduced through the urethra and withdrawn later after emptying the bladder when performing intermittent catherisation or after some time when

performing more or less permanent catherisation. In both applications, the medical device is sliding in direct contact with a physiological surface, the walls of the blood vessels or the mucosa of the urethra, respectively.

In order to reduce or avoid the risks of health and discomfort like inflammatory damage and degeneration caused by the medical device hydrophilic coatings having very low wet friction coefficient have been applied to the surface of the medical devices. Hydrophilic coatings having a low friction coefficient when wet typically comprise hydrophilic polymers such as polyvinylpyrrolidone (PVP), polycarboxyl acids, esters, salts and amides of poly(meth)acrylic acid, copolymers of poly (methyl vinyl ether/ maleic anhydride) and polyglycols like polyethyleneglycol (PEG).

According to Y. Fan (In Fan Y. L. 1990. " Hydrophilic Lubricious Coatings for Medical Applications," Amer. Chem., Polym. Mater. Sci. Eng., 63:709-716.), the methods described in the patent literature by which hydrophilic coatings can be applied onto a substrate can be roughly divided into 5 different methods:

(1) Simple coating with hydrophilic polymers,
(2) blending or complexing of hydrophilic polymers,
(3) formation of interpenetrating polymeric networks,
(4) coating with chemically reactive hydrophilic polymers and
(5) surface grafting of hydrophilic monomers.

The first three types of hydrophilic coatings have several disadvantages: they have low abrasion resistance giving the devices a short effective life time. A considerable amount of polymeric residuals is released at the site where it is introduced and at the same time, this loss of polymeric material rapidly increases the friction coefficient. This abrasion or dissolution may even be so pronounced that the reduction of the friction is not effective during all of the service period of the medical device and the low friction may even have vanished when the device is to be retracted.

The fourth method involves the use of chemically reactive hydrophilic polymers which are chemically bonded to substrates or primers containing e.g. aldehyde, epoxy or isocyanate groups. The fourth coating method suffers from the drawback of the use of toxic reactive materials and in order to avoid a residual toxic effect there is a demand of long reaction times and eventually washing steps in the process. US patent No. 4,373,009 discloses that a hydrophilic layer is formed on a substrate, e.g. wound drains, catheters, surgical tools and arteriovenous shunts, by binding unreacted isocyanate groups on the substrate surface and treating the surface with a hydrophilic copolymer made from vinyl-pyrrolidone monomers and monomers containing an active proton adapted to form covalent bonds with the isocyanate.

In European patent No. EP 0 166 998 B1 is disclosed a medical instrument having a surface having a reactive functional group covalently bonded with a water-soluble polymer of a cellulose polymer, maleic anhydride polymer, polyacrylamide or a water-soluble nylon (deriv.) and having lubricity when wetted. The substrate is treated with a solution of a compound containing the reactive functional group so that an undercoat is formed which contains this group. This is then coated with the water-soluble polymer which bonds to the functional group.

European patent application No. EP 0 289 996 A2 discloses a method for forming and applying a hydrophilic coating to a moulding in which process a solution containing a water-soluble polymer, more particularly polyvinylpyrrolidone or a copolymer thereof, one or more radically polymerisable vinyl monomers and a photo initiator is applied to the moulding and the applied solution is exposed to an UV radiation for curing purposes.

However this method needs more expensive process equipment and process control in order to avoid residual toxic monomers than the other methods.

In the fifth method, the hydrophilic polymers are typically polymerised from the corresponding monomers directly onto the surface of the medical device, giving a thin and uniform coating. However this method needs even more expensive process equipment and process control to avoid residual toxic monomers than the other methods.

WO 89/09246 discloses solid shaped structures having a surface coated with crosslinked hydrophilic polymer, the coating being durable and exhibiting a low coefficient of friction when wet. The hydrophilic polymer may e.g. be optionally substituted polyvinylpyrrolidones or other hydrophilic polymers or mixtures thereof. The coatings may be crosslinked using UV light in the presence of UV light-activated free radical initiators or using electron beam radiation. It is stated that the degree of crosslinking is critical and is controlled by the operating conditions chosen and that too much crosslinking reduces or completely eliminates the low friction surface property, and too little crosslinking negatively affects the durability of the coating.

Hydrophobic polymers like silicone and fluorinated carbon polymers has also been proposed as lubricant coatings. Coatings made from silicone and fluorinated polymers show low friction when dry as well as when wet rendering the devices difficult to handle. Another disadvantage related to these coatings is that they have considerably higher coefficients of friction when wet compared to most of the hydrophilic coatings.

Thus, there is still a widespread need of an easy processable polymeric system for applying low friction biocompatible hydrophilic coatings enabling a tight chemical bonding of the coating to different substrates, optionally after priming the same, giving hydrophilic coatings showing high abrasion resistance and low friction coefficients when wet and which reduce the use of noxious or irritating components.

Now it has surprisingly been found that coating comprising homo and copolymers of N-vinyl pyrrolidone (NVP) may undergo photopolymerisation or photocrosslinking during exposure to UV light in the absence of an UV light-activated free radical initiator. These polymers and copolymers can be crosslinked and chemically bonded to different substrates during exposure of UV-light to form hydrophilic lubricious crosslinked coatings which easily swells in water. Furthermore, it has been found that it is possible to produce a hydrophilic coating having a higher degree of cross-linking in the parts near the substrate.

BRIEF DESCRIPTION OF THE INVENTION

The present invention relates to a hydrophilic coating comprising a cross-linked polyvinylpyrrolidone.

The invention also relates to a medical device or other product provided with a hydrophilic coating comprising cross-linked polyvinylpyrrolidone.

Furthermore, the invention relates to a method for the preparation of a medical device comprising a hydrophilic coating comprising a cross-linked polyvinylpyrrolidone.

Still further, the invention relates to the use of polyvinylpyrrolidone for the preparation of a medical device or instrument comprising a cross-linked hydrophilic coating.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is described more in detail with reference to the drawing which shows a proposed structure of an embodiment of a hydrophilic coating according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to a hydrophilic coating comprising a cross-linked polyvinylpyrrolidone or copolymer containing N-vinylpyrrolidone, said coating having a higher degree of cross-linking in the parts near the substrate.

It has surprisingly been found that N-vinylpyrrolidone and copolymers containing N-vinylpyrrolidone and optionally a hydrophilic reactive prepolymer having vinylic unsaturation may be polymerised in situ using UV light in the absence of any photo initiator for forming a hydrophilic coating on a substrate, especially a medical device, showing a very high resistance against solution and/or abrasion and a low frictional coefficient when wet.

It is preferred that the polyvinylpyrrolidone has a molecular weight >100,000 giving the desired properties of the final coating. The molecular weight may e.g. be from 300,000 to 800,000 and is preferably about 500,000.

In a preferred embodiment of a coating of the invention a saturated polymer not taking part in the cross-linking is present. Such saturated polymer is used for controlling the hydrophilic properties of the hydrophilic coating.

A saturated polymer is preferably a hydrophilic saturated polymer. Hydrophilic saturated polymers are preferably selected from polysaccharides, polyvinyl pyrrolidone, polyvinyl alcohol, polyacrylic acid, polyethylene glycol and copolymers and blends of these.

When comprising a saturated hydrophilic polymer, the cross-linked coating of the invention preferably contains carboxymethylcellulose, cellulose acetate, cellulose acetate propionate, poly (methyl vinyl ether/ maleic anhydride), poly (meth)acrylic acid, polethylenglycols (PEG), polyamides, polyacrylic amides, poly vinyl alcohol which are physically bonded by entanglement in the crosslinked network.

In accordance preferred embodiment of the invention the coatings comprise an antibacterial agent such as a silver salt, e.g. silver sulphadiazine, an acceptable iodine source such as povidone iodine (also called polyvinylpyrrolidone iodine), chlorhexidine salts such as the gluconate, acetate, hydrochloride or the like salts or quaternary antibacterial agents such as benzalkonium chloride or other antiseptics or antibiotics. Antibacterial agents reduces the risk of infection, especially when performing urodynamic examinations.

In a further aspect the invention relates to a method for the preparation of a medical device having a cross-linked hydrophilic coating comprising polyvinylpyrrolidone or a copolymer of N-vinyl pyrrolidone, and optionally one or more saturated polymers, which method comprises dipping the device in a solution containing a polymer containing N-vinylpyrrolidone, and optionally one or more saturated polymers, optionally drying the coating and exposing the coated device to a UV light source for crosslinking .

In a preferred embodiment of the process, the device is dipped in a first solution containing a polymer containing N-vinylpyrrolidone, optionally one or more saturated polymers forming a primer coating, optionally drying the primer coating, dipping the device in a second solution containing a polymer containing N-vinylpyrrolidone, optionally one or more saturated polymers, optionally drying the coating and exposing the coated device to a UV light source for crosslinking.

In a preferred embodiment the primer coating is crosslinked by exposure to UV light before dipping the device in the second solution which enables a high degree of crosslinking of the primer coating reducing the swelling end increasing the wearing qualities and hence, the durability of the coating.

In a further preferred embodiment of the process the primer coating comprises a photo initiator which, together with PVP being partially swelled into the material of the device before crosslinking gives rise to a good physical and maybe even chemical binding further increasing the durability of the coating.

It has surprisingly been found that PVP coatings crosslinked through exposure to UV light have an excellent adherence to many polymeric substrates and therefore highly crosslinked PVP coatings in this invention are used as a primer for a topcoat of less crosslinked PVP.

By coating PVP coatings on a crosslinked primer coating and then crosslinking the top coating using only UV light and no photo initiator it is possible to obtain an integral coating having a top coat part easily swelling in water and thus providing slipperiness and a primer coating part having a higher degree of crosslinking reducing the swelling in water and providing durability in water.

In accordance with one embodiment of the method of the invention the crosslinked hydrophilic coating comprises coating polyvinylpyrrolidone(PVP) or N-vinylpyrrolidone copolymers onto a primer containing polyvinylpyrrolodene and a photoinitiator.

In accordance with another embodiment of the method of the invention the polymer comprising N-vinylpyrrolidone is coated on a primer coating comprising a mixture of polyvinylpyrrolidene and a hydrophobic oligomeric photoinitiator polymer which form an interpenetrating primer coat.

When using photoinitiators in the primer coating layer, it especially preferred to use photo initiators having two or three UV-functional groups giving rise to a more heavy and durable crosslinking thereof.

The hydrophilic coating of the invention may be attached directly to a substrate or, in some cases, it will be preferred to apply a primer coat on the substrate before applying the hydrophilic surface coating.

Thus, the hydrophilic coating of the invention may be attached directly to a substrate without applying a primer coat on the substrate. The substrate may alternatively be coated with a primer coat or primer system first for improving the

bonding of the hydrophilic coating to the substrate before applying the hydrophilic surface coating.

A primer coat may be a primer coat known per se and conventionally used for hydrophilic coatings for medical devices, typically an polyurethane base coat often used for PVC substrates or metals for guide wires or polyolefins or acrylates.

The hydrophilic polymers can easily be coated onto the substrate by any means known per se and reacted with the substrate or a primer. The not crosslinked hydrophilic polymer may e.g. be applied to the substrate by spray coating, dipping, rolling etc. in the form of a solution in water, or a solvent or a mixture thereof or as a dispersion in water.

Solvents for dissolving the hydrophilic prepolymers may for example be water, lower alkanols such as methanol, ethanol, isopropanol, keto alcohols such as diacetone alcohol, ketones such as acetone, methyl ethyl ketone (MEK), cyclohexanone, esters such as ethyl acetate, ethyl lactate, ether alcohols such as glycol ethers, polyethylene glycol 400, di and triethylene glycol, lactones such as gamma-butyrolactone, lactams such as 2-pyrrolidone, N-methyl-2-pyrrolidone, N-vinyl-pyrrolidone, amines, ethers, hydrocarbons and/or chlorinated hydrocarbons. The actual choice of solvent or solvent mixture is easily chosen by the person skilled in the art after routine experiments.

The chemical bonding to the substrate or to the primer can be effected through activation of an UV-initiator. The reactions which cause polymerisation and crosslinking can be obtained by using UV-light and UV-light activated free radical initiators and optionally co-initiators or accelerators, ionising radiation typically gamma radiation, electron beam radiation and X-ray, or by plasma treatment, ozone and corona or by thermal or catalyst activated free radical initiators such as peroxides and azo compounds.

To increase the degree of crosslinking in the PVP primer coating, it has been found that addition of photoinitiators gives a high crosslink density and polymeric photoinitiators are preferred because their tendency to migrate is extremely low. Especially ESACURE KIP 150 which is an oligo (2-hydroxy-2-methyl-1-(4-(1-methylvinyl)phenyl)propanone) or in other words a 2-hydroxy-2-methylpropiophenone modified oligo-alfa-methylstyrene are preferred because cleavage caused by exposure to UV light only forms residuals as acetone and 2-propanol which easily evaporates.

Polymeric photoinitiators based on 2-hydroxy-2-methylpropiophenone modified vinylic-, acrylic- or methacrylic monomers or polymers has also been found to give high crosslinking densities in PVP coatings.

Polymeric photoinitiator can also be used in the topcoat composition but are preferred only in the primer coat.

Photo initiators will normally be present in an amount from 0.1 to 10%, preferably from 0.1 to 7% giving a suitable degree of bonding and crosslinking to obtain a coating being easy to wet and showing a suitably low friction.

UV light sources which emit UV light with a wave length below 400 nm, preferably between 100 and 350 nm has been found to enablecuring.

Using a wave length above 300 only shows modest effect on crosslinking however addition of photoinitiators which absorb light energy, preferably from UV light increases the speed of cure or the crosslinking reaction of PVP and PVP-copolymers.

High light intensity in the UV range of 200-300 nm has been found to crosslink PVP and PVP-copolymers in less than 1 sec to form a water swellable but insoluble coating. It was found that the degree of crosslinking play an important role regarding swelling in water but also regarding the abrasion resistance and

adherence to the substrate. To high degree of crosslinking cause a decrease in water swellability and therefore an increase in friction. A too low degree of crosslinking gives a coating with a bad adherence to the substrate and a coating with no abrasion resistance.

The substrate may e.g. be metals, ceramics, plastics materials or polymers such as PVC, polyurethanes, polyolefins, EVA copolymers, polyesters or polyacrylates.

The coatings of the invention may comprise an osmolality increasing agent such as urea, sodium chloride and/or any salt or organic low molecular weight compound being physiological acceptable and non-irritating for adjusting the ion strength of the coating approximately to the physiological range, the coating preferably being isotonic in use.

When using urea, the added amount may vary within very broad limits. Thus, the coatings according to the invention may comprise from about 0.1% to about 60% and more preferred from 2 to 30% urea. When using about 10-30%, a rapid partial solubility is obtained giving a rapid formation of a slippery surface. Using higher amounts of urea in the range from about 30% to about 50%, an even lower friction is obtained somewhat slower.

The coating of the invention may also, if desired, comprise plasticizers such as diethylene glycol, glycerol, phthalates, sorbitol or the like.

To avoid auto-crosslinking of the unsaturated compounds of the prepolymer during storing and the manufacturing of the coating, inhibitors such as quinones may be added as polymerisation inhibitors.

Furthermore, agents for decrease of tackiness such as carboxymethylcellulose, cellulose acetate, cellulose acetate propionate, poly (methyl vinyl ether/ maleic anhydride) and polycarboxylates. may be added, if desired.

In accordance with a preferred embodiment pharmaceutically active compounds such as antimicrobial agents or antithrombogenic agents may be added to the composition.

It is especially preferred when the coatings of the invention comprise an antibacterial agent such as a silver salt, e.g. silver sulphadiazine, an acceptable iodine source such as povidone iodine (also called polyvinylpyrrolidone iodine), chlorhexidine salts such as the gluconate, acetate, hydrochloride or the like salts or quaternary antibacterial agents such as benzalkonium chloride or the like.

Indicators for pH or antibodies, e.g. monoclonal antibodies for specific proteins, may also be enclosed in the hydrophilic coatings of the invention

In a further aspect the invention relates to a medical device or other product provided with a hydrophilic coating comprising cross-linked polyvinylpyrrolidone, said coating having a higher degree of cross-linking in the parts near the substrate.

In a still further aspect the invention relates to the use of polyvinylpyrrolidone for the preparation of a medical device or instrument comprising a cross-linked hydrophilic coating said coating having a higher degree of cross-linking in the parts near the substrate.

The invention is explained more in detail with reference to the drawings.

DETAILED DESCRIPTION OF THE DRAWINGS.

Reference is made to the drawing which shows an embodiment of the invention having a substrate **1** having a hydrophilic coating **2** comprising hydrophilic polymer chains **3** being cross-linked **4** by polymerisation through radiation. In this embodiment, the hydrophilic coating has a higher degree of cross-linking in the parts near the substrate **1** which may be obtained by applying two layers, the

innermost of which comprises PVP and an accelerator, and the outermost of which comprising pure PVP.

MATERIALS AND METHODS

Polyvinylpyrrolidone: PVP K 90 available from ISP Inc. having a molecular weight 630,000.

Ethanol: Absolute Alcohol.

Gamma butyrolactone: Gamma-butyrolactone from International Speciality Products.

UV catalyst: ESACURE KIP 150 from Lamberti SpA.

Method for Determination of the Friction.

The Standard Test Method for Static and Kinetic Coefficient of Friction of Plastic Film and Sheeting, ASTM D 1894 - 93 was modified for testing the friction coefficient and wear on plastic tubes and catheters.

The tubes or catheters were cut in lengths of 10 cm and fixed on a stainless steel plate with two stainless steel rods as shown in ASTM D 1894 - 93. The rods had diameters comparable with the inner diameter of the tubes or catheters to keep their shape even when heavy sledges were placed upon them.

The friction was determined after wetting by dipping in water for 1 minute. The pulling force from the sledge was measured in Newtons.

The invention is disclosed more in detail with reference to the below working examples presenting embodiments of the invention. The examples are not to be considered as limiting the scope of the invention as set forth in the appended claims.

EXPERIMENTAL PART

EXAMPLE 1

Preparation of a catheter having a crosslinked single layer hydrophilic coating according to the invention.

5 parts of PVP K 90 was dissolved in 95 parts of a ethanol/gamma butyrolactone (85/15) solvent mixture. PVC catheters were dipped in the solution, dried for 30 minutes at 70°C and exposed to a UV light having a wave length between 200 and 300 nm for 6 minutes.

The catheter became lubricious in wet condition and had a high abrasion resistance.

EXAMPLE 2

Preparation of a tube having a crosslinked single layer hydrophilic coating according to the invention.

5 parts of PVP K 90 was dissolved in 95 parts of an ethanol/gamma butyrolactone (85/15) solvent mixture. Polyurethane tubes were dipped in the solution, dried for 30 minutes at 70°C and exposed to a UV light with a wave length between 200 and 300 nm for 6 minutes.

The tubes showed a low friction coefficient and a high abrasion resistance when abraded in water.

EXAMPLE 3

Preparation of a catheter having a crosslinked two-layer hydrophilic coating according to the invention.

5 parts of PVP K 90 and 0.05 parts of ESACURE KIP 150 were dissolved in 94.95 parts of an ethanol/gamma butyrolactone (15/85) solvent mixture. PVC

catheters were dipped in the solution and dried 1 minute at ambient temperature and then dipped in the PVP-solution used in Example 1. The catheters were further dried for 30 minutes at 70°C and exposed to UV-light at a wave length range between 200 and 300 nm. for 5 minutes.

The friction coefficient of the hydrophilic coating was lower compared to the single dip coating in Example 1 and 2.

EXAMPLE 4

Preparation of a catheter having a crosslinked two-layer hydrophilic coating according to the invention comprising urea.

5 parts of PVP K 90 and 0,05 parts of ESACURE KIP 150 were dissolved in 94,95 parts of an ethanol/gamma butyrolactone solvent mixture. PVC-catheters were dipped in the solution and dried 1 minute at ambient temperature and then dipped in a PVP-solution containing 5 parts of PVP, 1 part of urea and 94 parts of an ethanol/gamma butyrolactone (85/15) solvent mixture. The catheters were further dried for 30 minutes at 70°C and exposed to UV-light having a wave length range between 200 and 300 nm. for 5 minutes.

The friction coefficient of the hydrophilic coating was lower as compared to the friction coefficient of coatings prepared by a single as disclosed in Example 1, 2 and the coating prepared by a double dipping procedure as disclosed in Example 3.

EXAMPLE 5

Preparation of a catheter having a crosslinked two-layer hydrophilic coating according to the invention.

5 parts of PVP K 90, 1 part hydroxypropylcellulose and 0.05 parts of ESACURE KIP 150 were dissolved in 93.95 parts of an ethanol/gamma butyrolactone (15/85) solvent mixture. PVC catheters were dipped in the solution and dried 1

minute at ambient temperature and then dipped in the PVP-solution used in Example 1. The catheters were further dried for 30 minutes at 70°C and exposed to UV-light at a wave length range between 200 and 300 nm. for 5 minutes.

The friction coefficient of the hydrophilic coating was equivalent to that obtained with the single dip coating in Example 1 and 2.

EXAMPLE 6

Preparation of a catheter having a two-layer hydrophilic coating according to the invention having a higher degree of cross-linking in the layer near the substrate.

a) Formation of a primer coating layer with a high degree of crosslinking:
5 parts of PVP K 90 was dissolved in 95 parts of a ethanol/gamma butyrolactone (85/15) solvent mixture. PVC catheters were dipped in the solution, dried for 30 minutes at 70°C and exposed to a UV light having a wave length between 200 and 300 nm for 10 minutes for providing a crosslinked primer coating layer.

b) Formation of a top coat layer with a lower degree of crosslinking:
The catheters obtained in Example 6a) were dipped once again in the same solution, dried for 30 minutes at 70°C and exposed to a UV light having a wave length between 200 and 300 nm for only 5 minutes for providing a hydrophilic top coat layer having a lower degree of crosslinking and being easily swelleable.

The catheter became lubricious when wetted and had a high abrasion resistance.

EXAMPLE 7

Preparation of a catheter having a two-layer hydrophilic coating according to the invention having different compositions and having a higher degree of cross-linking in the layer near the substrate.

a) Formation of a primer coating layer with a high degree of crosslinking:

5 parts of PVP K 90 was dissolved in 95 parts of a ethanol/gamma butyrolactone (85/15) solvent mixture. PVC catheters were dipped in the solution, dried for 30 minutes at 70°C and exposed to a UV light having a wave length between 200 and 300 nm for 10 minutes for providing a crosslinked primer coating layer.

b) Formation of a topcoat comprising urea and having a lower degree of crosslinking:

The catheters obtained in Example 7a) were dipped in a PVP-solution containing 5 parts of PVP, 1 part of urea and 94 parts of an ethanol/gamma butyrolactone (85/15) solvent mixture. The catheters were further dried for 30 minutes at 70°C and exposed to UV-light having a wave length range between 200 and 300 nm. for 5 minutes for providing a hydrophilic top coat layer having a different composition and having a lower degree of crosslinking and being easily swelleable.

The friction of the hydrophilic coating was determined as described above.

The friction force of the coating prepared in Example 7 was lower than the friction force of coatings prepared by a single dipping procedure as disclosed in Example 1, 2 and also lower than the friction force of a coating prepared according to Example 6. The friction force of the hydrophilic coating prepared according to Example 7 was comparable to the friction force of a coating prepared by the double dipping procedure according to Example 4 without intermediate curing of the first layer. Thus, the coatings of the invention in the form of two-layer coatings show friction forces of the same order of magnitude as not-crosslinked coatings whereas crosslinked coatings of the invention comprising urea clearly shows lower friction than not-crosslinked coatings comprising urea.

COMPARATIVE EXAMPLE A

Preparation of a catheter having a primer coat and a non-crosslinked hydrophilic coating.

PVC-catheters were dipped in a primer solution of 4 parts of a medical grade thermoplastic polyurethane and 2 parts of nitrocellulose dissolved in 94 parts of THF and afterwards dried in an oven for 15 minutes at 60°C.
4.0 parts of PVP K 90 was dissolved in 96 parts of an ethanol/gamma butyrolactone (85/15) solvent mixture and coated onto the PVC-catheters and dried 1 hour in an oven at 60°C.

COMPARATIVE EXAMPLE B

Preparation of a catheter having a primer coat and non-crosslinked hydrophilic coating comprising urea.

PVC-catheters were dipped in the PU/nitrocellulose primer solution as made in comparative Example A and dried for 15 minutes before they were dipped in the PVP-solution containing 3.36 parts of PVP K 90, 0.64 parts of urea and 96 parts of an ethanol/gamma butyrolactone (85/15) solvent mixture. The catheters were further dried 1 hour.

Furthermore, the friction force was compared to the friction force of corresponding non-crosslinked coatings The results are summerised in the below table:

Initial Friction force measured on cross-linked and non cross-linked PVP coatings and cross-linked and non cross-linked PVP coatings comprising urea.

Example	Friktion force
1	0.14
2	0.15
3	0.10
5	0.10
6	0.11
Comparative A.	0.07
4	0.02
7	0.02
Comparative B	0.07

CLAIMS

1. A hydrophilic coating comprising a cross-linked polyvinylpyrrolidone or copolymer containing N-vinylpyrrolidone, said coating having a higher degree of cross-linking in the parts near the substrate.

2. A hydrophilic coating as claimed in claim 1, characterised in that the polyvinylpyrrolidone has a molecular weight > 100,000.

3. A hydrophilic coating as claimed in claim 1 or 2, characterised in that it comprises one or more saturated polymers.

4. A hydrophilic coating as claimed in claim 3, characterised in that the saturated polymer is selected from polysaccharides, polyvinyl alcohol, polyacrylic acid, polyethylene glycol and copolymers and blends of these.

5. A hydrophilic coating as claimed in claim 4, characterised in that the cross-linked coating contains carboxymethylcellulose, cellulose acetate, cellulose acetate propionate, poly (methyl vinyl ether/ maleic anhydride), poly (meth)acrylic acid, polethylenglycols (PEG), polyacrylic amides, poly vinyl alcohol which are physically bonded/entangled in the crosslinked network.

6. A hydrophilic coating as claimed in any of claims 1-5, characterised in that the cross-linked coating contains an antibacterial agent.

7. A method for the preparation of a medical device having a cross-linked hydrophilic coating comprising polyvinylpyrrolidone or a copolymer of N-vinyl pyrrolidone, optionally one or more saturated polymers, characterised by dipping the device in a solution containing a polymer containing N-vinylpyrrolidone, and optionally one or more saturated polymers, optionally drying the coating and exposing the coated device to a UV light source for crosslinking .

8. A method as claimed in claim 7, characterised in dipping the device in a first solution of a polymer containing N-vinylpyrrolidone, optionally one or more saturated polymers, forming a primer coating, optionally drying the primer coating, dipping the device in a second solution of a polymer containing N-vinylpyrrolidone, optionally one or more saturated polymers, optionally drying the coating and exposing the coated device to a UV light source for crosslinking.

9. A method as claimed in claim 8, characterised in that the primer coating is crosslinked by exposure to UV light before dipping the device in the second solution.

10. A method as claimed in claim 8 or 9, characterised in that the primer coating comprises a photo initiator.

11. A method as claimed in claim 10, characterised in that the polymer comprising N-vinylpyrrolidone is coated on a primer coating comprising a mixture of polyvinylpyrrolidene and a oligomeric photoinitiator.

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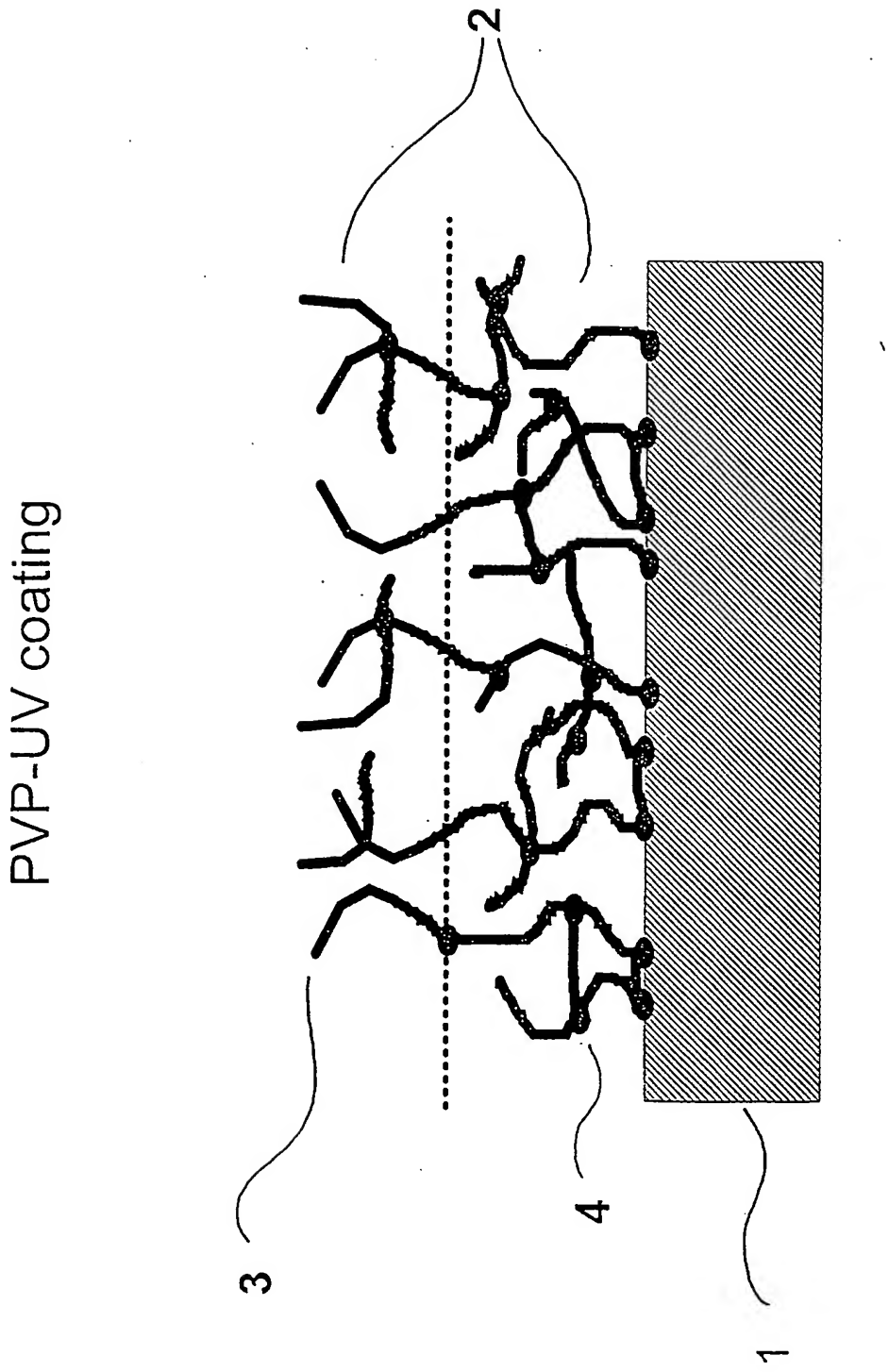

INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK 98/00265

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: C08J 7/04
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: C08J, A61L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, REGISTRY, CAPLUS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 8909246 A1 (E.I. DU PONT DE NEMOURS AND COMPANY), 5 October 1989 (05.10.89), abstract; page 3, line 31 - page 4, line 34; page 5, line 11 - line 15; page 6, line 25 - page 7, line 12; page 11, line 34 - page 12, line 15; example 4; claims 1-2, 21-24, 36, 41	1-7
A	--	8-11
A	EP 0289996 A2 (WILKINSON SWORD GESELLSCHAFT MIT BESCHRÄNKTER HAFTUNG), 9 November 1988 (09.11.88), column 3, line 23 - line 50	1-11
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
1 Sept 1998	14 -09- 1998
Name and mailing address of the ISA: Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Sofia Nikolopoulou Telephone No. +46 8 782 25 00

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK 98/00265

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4373009 A (R. ALASTAIR WINN), 8 February 1983 (08.02.83), abstract; column 4, line 41 - line 47; claims	1-11

INTERNATIONAL SEARCH REPORT

Information on patent family members

27/07/98

International application No.
PCT/DK 98/00265

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